Minutes of the
High Energy Physics Advisory Panel Meeting
July 11-12, 2005
Madison Hotel, Washington, D.C.

HEPAP members present:
- Keith Baker
- Joel Butler
- Alex Dragt
- Frederick Gilman, Chair
- Young-Kee Kim
- Paul Langacker
- Peter Meyers
- Stephen Peggs (Monday only)
- Steven Ritz

HEPAP member absent:
- JoAnne Hewett

Also participating:
- William Barletta, Director, Accelerator and Fusion Research Division, Lawrence Berkeley National Laboratory
- Frederick Bernthal, President, Universities Research Association
- Gerald Blazey, Department of Physics, Northern Illinois University
- Daniella Bortoletto, Department of Physics, Purdue University
- Raymond (Chip) Brock, Department of Physics and Astronomy, Michigan State University
- Aesook Byon-Wagner, Office of High Energy Physics, Office of Science, Department of Energy
- Robert Cahn, Physics Division, Lawrence Berkeley National Laboratory
- Robert Cousins, Department of Physics and Astronomy, University of California, Los Angeles
- Sally Dawson, Physics Department, Brookhaven National Laboratory
- Joseph Dehmer, Director, Division of Physics, National Science Foundation
- Persis Drell, Associate Director, Research Division, Stanford Linear Accelerator Center
- Thomas Ferbel, Office of High Energy Physics, Office of Science, Department of Energy
- Marvin Goldberg, Program Director, Division of Physics, National Science Foundation
- Judith Jackson, Director's Office, Fermi National Accelerator Laboratory
- Edward (Rocky) Kolb, Particle Physics Division, Fermi National Accelerator Laboratory
- Joseph Kroll, Department of Physics and Astronomy, University of Pennsylvania
- Joe Lykken, Particle Physics Division, Fermi National Accelerator Laboratory
- Marsha Marsden, Office of High Energy Physics, Office of Science, Department of Energy
- Akira Masaike, Director, Washington Office, Japan Society for the Promotion of Science

June Matthews, Director, Laboratory for Nuclear Science, Massachusetts Institute of Technology
F. M. O'Hara, Jr., HEPAP Recording Secretary
Nigel Sharp, Division of Astronomical Sciences, National Science Foundation
James Siegrist, Director, Physics Division, Lawrence Berkeley National Laboratory
Robin Staffin, Associate Director, Office of High Energy Physics, Office of Science, Department of Energy
Kenneth Stanfield, Deputy Director, Fermi National Accelerator Laboratory
James Whitmore, Program Director, National Science Foundation
Andreene Witt, Oak Ridge Institute for Science and Education
John Womersley, Office of High Energy Physics, Office of Science, Department of Energy

About 55 others were also present in the course of the two-day meeting.

Monday, July 11, 2005

Chairman **Frederick Gilman** called the meeting to order at 9:08 a.m. The theme of the meeting was addressing the open questions, as laid out in the HEPAP report, *Quantum Universe: The Revolution in 21st Century Particle Physics*, and addressed by the trillion-electron-volt colliders. The Panel will hear about the Large Hadron Collider (LHC), Tier-2 computing centers, the Linear Collider Subpanel report (to EPP2010), and the high-energy-physics resource study. He introduced **Robin Staffin** to present news from the Office of High Energy Physics (HEP).

For FY06, the markups from the Senate and House call for an annual HEPAP budget of \$735.9 million. There is \$30 million from Basic Energy Sciences (BES) to run the Stanford Linear Accelerator Center (SLAC) linac. The House focused on the International Linear Collider (ILC) and neutrinos (\$11 million was added for each); they see a synergy between the two elements. The Senate added \$3 million for facility operations to the President's request. The two versions will be reconciled in a House-Senate conference committee.

The charge to the Particle Physics Project Prioritization Panel (P5) has brought out a lot of fears. HEP wants an open discussion of future plans. The Office of Science (SC) plans to run the Fermilab Tevatron collider through FY09 and the SLAC B-Factory operations through FY08. P5 is being asked to consider what factors or considerations might lead to completing B-Factory operations one or two years earlier than planned, when would one be in a position to make such a determination, and what information would be needed. Similarly, for the Tevatron collider, it is being asked what factors or considerations might lead to completing operations one or two years earlier than now planned. A lot of questions could be raised, such as when would one be in a position to make such a determination and what information would be needed. The reaction was stronger than anticipated. SC is not trying to have a predetermined judgment validated. What is wanted is a transparent discussion. The purpose is to get the greatest science possible.

This charge must be considered in an international context. This is a national program, but P5 membership includes some people from other countries. This exercise is a weighing of the future versus the present. The budget outlook is flat except for the ILC. DOE and NSF will be reviewing the accelerator R&D program. A good study will have value to other fields.

The total support for accelerator R&D, including ILC R&D and the LHC Accelerator Research Program (LARP), is about $68 million in FY05. HEPAP is to conduct a comprehensive review of all aspects of the accelerator R&D programs supported by DOE/HEP and NSF/EPP [Elementary Particle Physics]. The draft report is due by the end of October 2005. The charges to this subpanel are so central to the life of HEP that it is good to discuss them.

The Office of HEP will get a new Intergovernmental Personnel Act (IPA) detailee in August and has added several new staff members. Aesook Byon-Wagner has gotten the new assignment of Acting Deputy Associate Director. There was also a retirement: Dave Sutter, the Leader of Advanced Accelerator R&D Technology, who had a long and distinguished career at DOE, building and sustaining a strong and world-leading accelerator research effort. There are four positions still to be filled:

- Leader of Advanced Accelerator R&D Technology,
- Budget and Program Planning,
- Project Management, and
- Program Manager for Accelerator R&D Technology.

Two division directors are to be named, but they will be double-hatters. These changes follow the recommendations of the Committee of Visitors (COV).

Universities and laboratory managements need to examine the possibility of supplying IPAs to the effort. Maintaining a strong team on the DOEOHEP is a necessary but not sufficient condition for a strong HEP program.

Peggs asked if the Accelerator R&D Subpanel was staffed. Staffin replied, no.

Dragt asked if Staffin could comment on the Rare Symmetry-Violating Processes (RSVP) panel and the International Thermonuclear Experimental Reactor (ITER). Staffin said that neither of those was in his purview and he could not speculate.

Kim asked whether, in Uppsala, he had discussed having conferences among international funding agencies. Staffin answered that the possibility was discussed, although he had not received any subsequent feedback from that meeting. HEP would be happy to meet with the collaborations, but it would be easier to discuss future plans with just the funding agencies, giving priorities and intentions.

Barletta asked if Staffin saw the SC subcommittee on accelerators affecting HEP's study. Staffin replied that the SC subcommittee will inform the HEP study but not compete with it.

Gilman then asked **Joseph Dehmer** to review the status of the NSF's Directorate for Mathematics and Physical Science.

The FY06 budget has received House and Senate markups. The House has recommended a 3% increase in the budget from FY05, the Senate has recommended a 1% increase; the budget request had asked for a 2% increase. There will not be any big shockers. Both the House and Senate funded Ice Cube and were noncommittal on RSVP. Since December, when a cost escalation of RSVP was recognized, there have been two studies that gave clear analyses. A presentation to the National Science Board (NSB) is being prepared; the NSB will make a recommendation. A solicitation has been issued for the science case and site recommendations for an underground laboratory; eight sites were identified and evaluated. The evaluations were sent to the principal investigators (PIs), and their responses have been considered by the panel. A small number of sites will get funds for a conceptual design report (CDR). In early August, those sites will be announced.

The NSF benefits from a good crew of program managers in particle physics. Some of them are IPAs and have to return to their institutions after 3 or 4 years. James Whitmore will be going back to Pennsylvania State University and will need to be replaced. A position in particle astrophysics has also been posted. A position for the Laser Interferometer Gravitational Wave Observatory (LIGO) has been closed.

The priorities at NSF are

- Cyberscience,
- Nanotechnology,
- Maintaining a strong core of R&D, and
- Stewardship of facilities.

The Division has a COV coming up, covering all of physics, looking at everything that is done, and assessing how the Division serves the community. The COV will occur in February, and members are being sought now.

Dragt asked where mathematics fits in. Dehmer replied that it is a separate division.

Theory support is being increased 5% per year for a number of years. The driver is a large influx of young theoretical physicists. Also, it is easier to increase a small program than a large one, especially in tight budget times.

An LHC funding profile was worked out that will build up NSF support. That ramp up put pressure on the CLEO-c program at Cornell. Making sure that data come out of CLEO-c is important.

Because of the response to *The Physics of the Universe* report, particle nuclear astrophysics funding is increasing, but the interagency working group still considers it a current issue. A lot of planning is being done by the Astronomy and Astrophysics Advisory Committee (AAAC), HEPAP, Neutrino Scientific Assessment Group (NuSAG), and others who are feeding information to the FACA [Federal Advisory Committee Act] groups. HEPAP needs a Subpanel on Dark Matter to determine a best strategy.

Ritz asked when the proper time would be to select a director for the underground laboratory. Dehmer said that the project will go to the CD phase without a director. A world-class scientist would probably not want to take on the leadership while several sites are still being considered. But during the next cycle, a director will probably need to be involved to put together the CD package. At that stage, management is a critical factor and determines the risk and success of the endeavor.

Bernthal asked Dehmer if he had any thoughts on funding profiles for an underground laboratory. Dehmer responded that a technical design would be needed to do that.

Kroll asked how much it will cost and what guidelines there were for its use. Dehmer replied that the expected cost is $100 million and that there are no guidelines, yet. The different disciplines will contribute to the financial burden. The Physics Directorate has shouldered the costs so far and probably will carry most (80%) of the financial burden.

Kim suggested going back to discussing ITER. Strauss said that ITER's funding was cut by 50% because there was no director and no site chosen when the funding decisions were made.

Jackson thanked NSF for funding staff members in communications.

Gilman declared a break at 10:24 a.m. and called the meeting back into session at10:46 a.m., asking **Thomas Ferbel** to report on the U.S. Large Hadron Collider (LHC) Program.

Interest in the LHC blossomed after the Superconducting Super Collider (SSC) was terminated. U.S. involvement in LHC was placed before HEPAP in 1994, with a subpanel recommending that the United States declare its intention to join other nations in constructing the LHC and initiate negotiations. DOE and NSF negotiated a U.S.–CERN [Conseil Européen pour la Recherche Nucléaire] international agreement for U.S. participation, with DOE agreeing to provide $450 million and NSF $81 million to build components for ATLAS [A Toroidal LHC ApparatuS], CMS [Compact Muon Spectrometer], and the LHC machine. The agreement was formally signed in December 1997, which was after the R&D had commenced. A memorandum of understanding (MOU) between DOE and NSF was signed in June 1998 establishing the agencies' Joint Oversight Group (JOG) for the U.S. LHC effort. As a result, the United States became a major contributor to ATLAS [with Brookhaven National Laboratory (BNL) as the host laboratory] and CMS [with Fermi National Accelerator Laboratory (FNAL) as the host laboratory], providing about 25% of the personnel. FNAL, BNL, and Lawrence Berkeley National Laboratory (LBL) formed the U.S. LHC Machine Collaboration with Fermilab as the host lab. A construction project was established under guidelines set by the international agreement, the DOE–NSF MOU, and a Congressionally mandated cap of $531 million for fabrication of all deliverables ($200 million for the accelerator and the rest for the detectors). The U.S. ATLAS, CMS, and LHC Machine collaborations

- agreed via MOUs on deliverables with ATLAS, CMS, and CERN;
- established excellent working relationships with their international counterparts; and
- provided U.S. deliverables on schedule and within budget.

He showed the profile of construction funding; construction will end in FY07. The United States has gotten a lot out of this effort, such as the CMS end-cap muon station with the cathode strip chambers and ATLAS, which is close to completion. A research program was envisioned to provide technical support for executing research after construction. As the construction project started to take root, the research program started in FY00, having an inflection point in the funding profile in FY05 and attaining a steady state beyond FY07 (guidance for the level of funding is yet to be fully reviewed). The research program also includes the upgrade of the detectors and the accelerator for an eventual LHC luminosity of $10^{35}/cm^2$-s. A large part of the core program in DOE/HEP and NSF-EPP is expected to contribute to all aspects of the U.S. LHC Program. The first "running" is likely in mid-2007, with decent data in 2008. This program will be one of the major U.S. HEP/EPP programs for the next 15 to 20 years. The achievements and success of all components of the U.S. LHC Program are attributable to the U.S. experimenters' managing and executing the construction and research activities. He showed the organization chart of the program.

Flushed with success from the construction effort, the United States is positioning itself to be an effective player in the running of the experiments and in uncovering the physics once the LHC starts. Much physics-directed analysis is in full swing on Monte Carlo events, with great interest and input from U.S. phenomenologists. Things look like they are going in the right direction. The fabrication of U.S. deliverables is nearly complete. The construction effort is in various stages of testing, installation, and commissioning. The U.S. part of the LHC will be 98% complete at the end of this fiscal year. More information is available at www.ch.doe.gov/offices/FAO/projects/uslhc/pep/index.html.

Two major parts of the effort, aside from construction, are (1) the U.S. ATLAS and U.S. CMS experiments and (2) the U.S. LARP. The first encompasses software and computing (S&C), including facilities, core software, grid software, and support of analysis; maintenance and operations (M&O) of the components made by the United States, including pre-operations; and detector R&D for the eventual luminosity upgrade of the LHC. The second includes fundamental accelerator physics, commissioning of the accelerator, beam instrumentation, tuning of the feedback and collimation, and R&D on the superconducting Nb_3Sn magnet for upgrade.

Some of the features of the program include extensive planning and regular oversight (both external and internal DOE–NSF reviews and discussions. The main costs involve human resources. Experts are not off-the-shelf commodities. Long-term planning and budget stability are key factors. The bulk (about 80%) of DOE funding is for experiments, with NSF providing another 35% of the DOE part. The other 20% of DOE funding is for LARP, which is funded exclusively by DOE. The success of the United States rests on the expected shift of interest and scientists from current core-program activities to the LHC. Eventually, perhaps more than 50% of U.S. experimenters may join the program. Networking resources for effective data transfer comprise an essential ingredient for success of U.S. participation in the LHC. DOE and NSF are working on these resources.

The budget profile for the DOE and NSF LHC research program is substantial (about \$1 billion during the next two years). The program has had regular reviews of ongoing activities to make sure the program is going in the right direction. It had a review by the M&O Evaluation Group (MEG) at Fermilab on Jan. 27-29, 2005. Comments received include:

- U.S. ATLAS and U.S. CMS M&O are being managed effectively; the managers are alert to problems and doing well.
- The M&O scope and cost estimates proposed by the collaborations are reasonable.
- U.S. CMS and U.S. ATLAS have demonstrated significant progress in their M&O plans despite tight budgets. Fiscal years 05 to 08 are considered critical years for the commissioning of the ATLAS and CMS detectors, their preparation for start of operations, and assuring sufficient detector integration and readiness for data in 2007.
- Of major concern is the low contingency for unforeseen needs.
- These programs rely strongly on support from the core program, including support for physicists working at CERN, and might require additional support to maintain a successful M&O effort.
- The preliminary plans for detector R&D for the LHC upgrade are reasonable; the level and focus of the R&D effort appears commensurate with current LHC upgrade plans in general.

There has also been an intensive S&C review of U.S. ATLAS and U.S. CMS. In general, reviewers were pleased with the leadership and work of the U.S. teams, but voiced some concern about U.S. CMS's overextension of responsibilities. James Whitmore will talk about the Tier-1 and Tier-2 centers. Recent completion of computing models and subsequent reviews led to significant revisions in the required resources, which have been incorporated into the latest plans. The review committee expressed concern about dependence of U.S. deliverables on funding from external grid projects (some of limited duration). DOE and NSF are trying to help alleviate this problem. The review committee was especially pleased with the analysis at the LHC Physics Center at Fermilab. It was seen as being advantageous for the U.S. CMS physics program and involvement in LHC from afar. It asked for clarification of the "Virtual Corridors" model for support of physics analysis, and U.S. ATLAS will respond soon.

The third part reviewed was LARP. The Committee was pleased with LARP progress and convinced of the importance of the tasks at hand. Seeing whether a quadrupole of high field strength, large aperture, and large length (>4 m) can be built from an Nb_3Sn superconductor will be of great value to accelerator community, not just to the LHC. The review committee said that other components of the LARP program (collimators, luminosity monitors, tune feedback, etc.) form major contributions to the LHC program and are worthy of full support. Building the prescribed quadrupole magnet as a proof of principle is not an easy matter and requires the use of all available U.S. magnet expertise. The aperture is 110 mm. The review committee had some concerns about the technical goals of LARP and requested a detailed technical review of LARP R&D, which will be provided by the end of the year.

As the construction funding ramps down, the operations funding ramps up.

Three fantastic (bargain) opportunities for U.S. involvement in physics are

- ALICE [A Large Ion Collider Experiment]
- ATLAS, and
- CMS.

All three want U.S. participation. ALICE is keen to introduce jet-trigger capability [a recent need resulting from discoveries at the Relativistic Heavy Ion Collider (RHIC)] and will go ahead with such goals with or without U.S. participation but will go faster with U.S. help. Both ATLAS and CMS want U.S. nuclear physicists to lead these efforts. They already have the important jet triggers, but need some calorimetry at zero degrees to make sure the heavy-ion programs work well. In 2002, the Nuclear Science Advisory Committee (NSAC) said that it is "wise to make modest investment," especially for complementary issues in heavy-ion physics that cannot be addressed through a program in the United States. The Barnes report in 2004 said that "Participation at LHC should become a new component of the U.S. HI program, ... comparable in investment priority with upgrades of each of the two large RHIC detectors." This statement assumed budgets at a constant level of effort. With current funding uncertainties, the FY06 and FY07 budgets will determine the direction of involvement. Three separate groups are eager to join ALICE, ATLAS, and CMS, with some implications for RHIC and the rest of the nuclear physics community. Some of these groups are smaller experiments that were running on RHIC.

The current status is that the U.S. LHC fabrication project and research programs are well managed, making good progress, and experiencing excellent international cooperation. The current ramp up of support for the research program is crucial for readiness for the first beam in 2007 and for developing detectors and interaction-region (IR) magnets for the upgrade. Although budgets are tight, priorities and direction have been reviewed and supported by committees of experts. The United States is keeping up well with other countries (in LARP as well as in preparation for the physics analysis). U.S. collaborations at the LHC cannot succeed without the expected migration from ongoing commitments in the U.S.-based research program. There is concern that this migration might occur in panic. There have been some communication (and language) problems between the United States and CERN; but overall, there has been good cooperation at all levels. One aspect that is lagging is communication among scientists. Funding for support of U.S. personnel abroad is a concern for all (including LARP). Resources for funding of LHC hardware commissioning are still unclear.

Assuming no major surprises, finishing the accelerator by July 2007 will be a magnificent accomplishment. (Some naysayers may think this unlikely, but nobody is betting against success.) Some components of the detectors may not be completed, but the detectors will be functional and capable of taking data by mid-2007. The CMS forward crystals will not be ready until 2007, and pixels will be installed in 2008 (delayed to protect them from the initial beam). ATLAS also has some trepidations about readiness; but assuming no disasters, both experiments expect to be in good shape for the first data run in spring of 2008. The initial luminosity may not be much higher than that at Tevatron, but cross sections of interest will be far larger, and the results are expected to be very exciting. Anything that can be measured will be interesting and publishable. Surprises happen, however; problems will occur, but the scientific wherewith all is available to recover.

Langacker asked what happened with the support structure for the quadrupole lines. Ferbel replied that the repair work is progressing well, and it will not be a showstopper.

Ritz asked how one "plans for upgrades" coming at the same time as other possibilities for U.S. programs. Ferbel answered that the R&D problems have been examined, and work is in progress to correct those problems in an upgrade. About $4 million will be spent in the R&D program for upgrades. Funds for the accelerator and detectors will not be requested until FY09. The scale is about $100 million per experiment. Ritz asked if that was part of the budget for LHC or if it was additional funding. Ferbel responded that it was not a done deal.

Kim asked about the personnel plans. Ferbel answered that the plans for resources are supposed to be presented in August. With CMS having a large focus at Fermilab, that will require less travel; ATLAS will require more travel to CERN. Kim pressed on to ask whether one knows what that means with a constant budget. Ferbel replied that it is too soon to tell.

Bortoletto said that she was concerned that planning for the detectors was not further along. Ferbel said that it is in the budget but may not be at the right level.

Gilman asked **James Whitmore** to present an update on the LHC Tier-2 centers.

The Grid-based LHC Discovery Machine feeds data from an experiment into the CERN Computer Center. From there, the data go to Tier-1 centers in Korea, Great Britain, Russia, the United States, and elsewhere. Those centers forward the data to their respective Tier-2 centers, where they are stored. Some selected data are then stored in physics caches in Tier-3 centers at institutions. Finally, the data summaries are downloaded onto the desktop machines of individual scientists.

Grid refers to geographically distributed computing resources configured for coordinated use. Those physical resources and networks provide raw performance capability and are controlled by their owners and shared with others. Software (middleware) ties the tools, services, etc. together.

Cyberinfrastructure refers to assets based upon distributed computer, information, and communication technology (i.e., it includes the enabling hardware, algorithms, software, communications, institutions, and personnel).

The Sloan Digital Sky Survey has been producing tens of terabytes from 2001 to the present. LIGO started producing hundreds of terabytes in 2002. The experiments at the LHC will produce tens of petabytes per year starting in 2007. To handle this crush of data, NSF has been integrating universities and laboratories in a national cyberinfrastructure with international interoperability, working with Grid3, which is changing into the Open Science Grid (OSG).

The cooperative effort of the Grid Physics Network (GriPhyN), International Virtual Data Grid Laboratory (iVDGL), and the DOE Particle Physics Data Grid (PPDG) is referred to as Trillium. Its purpose is to develop the technologies and tools needed to exploit a Grid-based cyberinfrastructure, apply and evaluate those technologies and tools in challenging scientific problems, develop the technologies and procedures to support a permanent Grid-based cyberinfrastructure, and create and operate a persistent Grid-based cyberinfrastructure in support of discipline-specific research goals but usable by many disciplines. It employs about 150 people.

Grid3 has been very successful. It is part of the LHC Grid. Its applications are HEP, LIGO, Sloan Digital Sky Survey (SDSS), Genomics, and the Computer Science Testbed. Grid3 is phasing into the Open Science Grid. Its roadmap calls for it to build upon existing achievements towards a sustained U.S. national production grid for the long term (past 2010); for the U.S. LHC to build and contribute its resources into a coherent infrastructure to provide the initial federation; in the meantime, OSG is to develop the general Grid infrastructure to support other sciences; and everyone will work toward forging a partnership among application scientists, technology providers, and resource owners.

CMS is bringing up services on three new Tier-2s (Massachusetts Institute of Technology, University of Nebraska, and Purdue University) and four Tier-2C sites (California Institute of Technology, University of California at San Diego, University of Florida, and Wisconsin University). "Tier- 2C" means it will also develop grid technology for other disciplines on their campus. Tier-2s for CMS will participate in the LHC Computing Grid (LCG) Service Challenge 3 [SC3]. The Tier-2 centers are deploying the production version of the Open Science Grid software stack (OSG 0.2). All Tier-2 centers will be involved in simulated event production and will ramp up analysis activities.

The Tier-2 goals are to

- Provide processing by deploying 40 to 60 boxes (80 to 120 CPUs) at each Tier-2 site this year.
- Deploy 20 to 40 TB of cached space this year.
- Provide networking.
- Install Grid interfaces and CMS-specific services.

The progress made includes

- The U.S. CMS recently received an NSF award for the Data Intensive Science University Network (DISUN) for Tier-2C as a joint EPP/SCI venture ($2 million per year for 5 years).
- The DISUN work plan is now starting.
- NSF's Computer and Information Science and Engineering/Shared Cyberinfrastructure (CISE/SCI) has a definite interest in this because the Tier-2Cs will be developing grid technology for both EPP and other disciplines in science.

Discussions are now being held with U.S. ATLAS on how to help satisfy their needs and also to further the progress of general Grid technology for other users. U.S. ATLAS has recently selected three Tier-2 Centers: one Tier-2 at the University of Chicago and Indiana University and two Tier-2Cs at Boston University and Harvard and at the University of Texas at Arlington, University of Oklahoma, Langston University, and University of New Mexico. They are already working and are major producers of ATLAS data. They need to function as part of the ATLAS Computing System Commissioning/Service Challenges in 2005. SC3 and SC4 are scheduled for midsummer 2005 and the beginning of 2006.

Tier 2 centers will play a vital role in ATLAS. They are the only resource for the large simulations needed to fully understand the systematic errors in ATLAS. They are also a prime resource for physicists to do analysis. Worldwide, there are approximately 30 Tier-2s in ATLAS. The approximate overall ATLAS capacity in 2008 will be 21 MSI2k CPUs and 9 PB of disk capacity. 20% of this capacity will be in the United States to satisfy commitments to ATLAS. U.S. Tier-2s now have 0.1 MSI2k CPUs and 10 TB of disk capacity; in 2008, they will need 1.3 MSI2k CPUs and 600 TB of disk capacity.

There was a recent Rome Physics Workshop. Three of the top five contributions in ATLAS were from the United States.

A plot of the number of jobs run each day indicates that CMS dominated from February to mid-June 2005, ATLAS dominated from mid-June to mid-October 2005, and usage has been about equal between CMS and ATLAS since then.

In the Trillium grid partnership, DOE's PPDG provided $12 million between 1999 and 2004, NSF's GriPhyN provided $12 million between 2000 and 2005, and NSF's iVDGL provided $14 million for 2001 to 2006. The basic composition of these organizations is 4 universities and 6 laboratories for PPDG; 12 universities, San Diego Supercomputing Center (SDSC), and 3 laboratories for GriPhyN; and 18 universities, SDSC, 4 laboratories, and some foreign partners for iVDGL. GriPhyN ended in FY04. iVDGL is continuing, with its last funding coming in FY05. Ultralight just started last year.

Support for OSG, LCG, and Enabling Grids for E-Science in Europe (EGEE) cooperation is $0.25 million. However, some of these efforts are expiring soon. The question then arises of how to sustain the OSG. There are discussions about Trillium sites' providing Grid infrastructure to Quarknet sites and/or having the Quarknet Education and Outreach Program expand to teach infrastructure as well as quarks/cosmos.

GriPhyN and iVDGL have outreach sites at the University of Texas at Brownsville, Hampton University, Salish Kootenai College, and Florida International University.

The target date for proposal submissions to the Division of Physics that are competing for FY06 funds is September 28, 2005. The deadline for the Faculty Early Career Development Program is July 19, 2005.

Womersley said that his understanding was that, worldwide, the centers were in the Tier-2 model, not the Tier-2C model. Whitmore replied that it might vary from country to country. Obviously, the Grid is going to be applicable to more than just the LHC. At least in the United States, the Tier-2Cs will go beyond particle physics. Goldberg added that, in the past, many people had to travel to CERN to conduct experiments. It is hoped that these centers will mitigate some of the travel needs and costs through their collaborative tools.

Ritz asked if any surprises had occurred during the challenges. Whitmore noted that Monte Carlo jobs are not being submitted on the Grid yet. There are lessons being learned.

Gilman declared a break at 12:03 p.m. and called the meeting back into session at 1:36 p.m. He asked **Peter Meyers** to report on the HEPAP-NSAC NuSAG.

The NuSAG has had a lot of activity but has not reached any conclusions yet. He listed the membership of the Group, a joint HEPAP-NSAC working group.

The charge to the Group noted that previous studies had done an excellent job of explaining the new paradigm of neutrino science, why this science is filled with important and interesting questions, and why the time is right to address these questions. It asked NuSAG to make recommendations on the specific experiments that should form part of the broad U.S. neutrino-science program.

First, the Group is to assess a multidetector reactor experiment for studying ν_e disappearance down to the mixing angle $\sin^2 2\theta_{13} = 0.01$. The experiments to be looked at include

- A U.S. experiment (in Braidwood, Illinois, or elsewhere),
- U.S. participation in a European reactor experiment (at Double Chooz or elsewhere),
- U.S. participation in a Japanese experiment (not a lot of U.S. activity right now), and
- U.S. participation in a Chinese reactor experiment (at Daya Bay).

Second, the Group is to address the American Physical Society study's recommendation of a phased program of sensitive searches for neutrino-less nuclear double beta decay. There are U.S.-based experiments [Majorana, which is well along in the proposal process; Enriched Xenon Observatory (EXO), an R&D project; and others using different nuclei and techniques]. There are also possibilities for U.S. participation in an Italian experiment (Cuoricino/Cuore), a Japanese experiment [MOON (Molybdenum Observatory of Neutrinos), which is in an early R&D phase], and a French experiment [SuperNEMO (Neutrino Ettore Majorana Observatory), which is in its fourth phase of an ongoing experiment with a small U.S. contingent].

Third, the Group is to assess accelerator experiments with a sensitivity of $\sin^2 2\theta_{13} = 0.01$ and sensitivity to the mass hierarchy through matter effects. If $\sin^2 2\theta_{13}$ is large enough, charge-parity (CP) violation may be observed. The experiments to be looked at include

- U.S. participation in the Tokai-to-Kamioka (T2K) experiment at the Japan Proton Accelerator Research Complex (JPARC) in Japan (two efforts are proposing U.S. participation);
- Construction of a new off-axis detector to exploit the existing Neutrinos at the Main Injector (NuMI) beamline from Fermilab to Soudan, Minnesota, as proposed by the NuMI Off-Axis ν_e Appearance (NOvA) collaboration, which itself just got Phase 1 approval from Fermilab;
- Main Injector Oscillation Search (MINOS), which is just starting to take data;
- As above but using a large liquid-argon neutrino detector (the effort is actually focused primarily on longer-term applications); and
- Two U.S. T2K efforts: B280 (in which the accelerator is 280 m from the detector) and 2km (in which the accelerator is 2 km from the detector).

In each of these three cases, NuSAG is to look at the scientific potential of each initiative and then recommend a strategy of one or more experiments in that direction that should be pursued as part of the U.S. program.

Ritz asked whether the charge also spoke to the quickness with which these experiments could be conducted. Meyers responded, yes; the Group has a tight time schedule for getting recommendations in:

Letter to experiments requesting input: May 11
NuSAG members on board: May 16
First meeting: May 31 to June 2
Presentations from all experiments (first on double-beta decay and then on others)
Questions sent to experiments: June 16 to July 8
Second meeting (mostly double-beta decay): July 17 and 18
Double-beta-decay report delivered to NSAC and HEPAP: early August
Third meeting: early September
Reactor and accelerator report delivered to NSAC and HEPAP: late September.

At the current time, NuSAG is completing the information-gathering phase and entering the recommendation phase to respond to the first round of charges. Now it gets difficult. And there are some broader issues:

- Is NuSAG "the PAC" [program advisory committee] for neutrino physics?
- Where does the technical assessment come in this process?
- Is NuSAG the gatekeeper for new initiatives?
- How do experiments get considered after NuSAG?

NuSAG must report to lots of places: DOE and NSF (and NSAC, HEPAP, P5, etc.). This reporting procedure will be worked out as the process progresses. The process for follow-on activities is still being developed. Maybe there will be another round of experiments. If so, NuSAG could judge bang for the buck.

Langacker asked him to address the roles being played by the United States. Meyers said that the Group is juggling some experiments that are totally funded by the United States and some that the United States is just playing a small role in.

Kim asked how much funding for the Chinese experiment is approved. Meyers responded that he did not know. Kim went on to ask how much U.S. participation there is in the Chinese experiment. Meyers responded, quite a bit in the detectors; this is an international project, not a Chinese experiment.

Ritz noted that the charge distinguishes between assessments of short-term and long-term experiments and asked about the time horizon. Meyers answered that some experiments are proposed and ready to go. A few (e.g., EXO and MOON) are not that much developed but are not asking for very much money. The period from 2008 to 2010 is where these funding requests are expected because that is when current experiments ramp down. The community has to have these things in mind.

Staffin asked about the difference between a PAC and a SAG [science advisory group]. Meyers stated that a PAC gets a slate of experiments and decides among experiments on the basis of scientific and technical aspects. A SAG is more ad hoc; some experiments come to the SAG, and some do not.

Kim asked how the approval of NOvA related to NuSAG's assessment. Meyers said that NuSAG is trying to pick up where the Fermilab PAC left off. It does not want to second guess, but it cannot ignore what has occurred. Staffin commented that a $200 million experiment is not going to fly on a PAC's say so. There has to be a national endeavor. Stanfield noted that Phase 1 identifies what should be proposed to the funding agency, and Phase 2 is when funding has been secured.

Siegrist asked if NuSAG was looking at everything out there. Meyers answered, yes; at least the Group has to know about it.

Drell asked about P5. Meyers replied that they will probably want to know how this Group's deliberations are shaping up. The hope was that these groups inform each other.

Cousins noted that where the technical assessment is done is important. For NOvA, the technical assessment has been done over a lot of years. Others have not had that experience. Meyers responded that that issue made him nervous; NuSAG's ability to judge the relative technical issues is limited.

Masaike asked if NuSAG was going to judge NOvA Phase 2. Meyers stated that NuSAG is just considering Phase 1 of NOvA or Phase 1 of T2K. The charge asks the Group to look at experiments that have a good chance of success or of subsequent phases. Thus, a possible upgrade path may be a plus, but the Group is not looking at the second phases themselves.

A call was made to JoAnne Hewett in England to participate in the report on the LHC/ILC Subpanel; the attempt to contact her was unsuccessful. **Joe Lykken** presented the Subpanel's report.

This is the Subpanel's second progress report. He listed the membership of the Subpanel. The Subpanel has a hard deadline of August 2 for giving input to the EPP2010 National Research Council Committee. This requirement conflicted with the broader aspects of the Subpanel's charge from HEPAP and with requests it heard during its April 22 meeting with Washington customers. Its solution is to produce two reports, the first for EPP2010 and a later document for a wider audience. A draft of the EPP2010 document has been distributed. The second report will be ready early this fall. The overall schedule has been

March 25: first meeting held at the Linear Collider Workshop in Palo Alto
March 30: first weekly teleconference held
April 22: meeting in Washington with J. Marburger, M. Turner, R. Staffin,
P. Looney, M. Holland, J. Parriott, and K. Carroll
April 23: writing started
June 16-July 8: ten writers/editors iterated on a daily basis
June 24: first complete pre-draft sent to R. Staffin and M. Turner

July 1: first draft circulated to some leaders of the community

July 8: new draft report sent to HEPAP

The Subpanel is loaded with people who have connections to a broad range of communities. JoAnne Hewett is a member of the LHC/ILC Study Group, and the Subpanel is coordinating with the ILC Worldwide Study Group. Feedback on the first draft has been solicited and received from leaders of the LHC and of the ILC. Before finalizing the report for EPP2010, the Subpanel will incorporate feedback from other sources as well:

- National laboratory directors;
- More leaders of the LHC, ILC, and noncollider communities; and
- HEPAP.

It will also work with the community post-EPP2010 (e.g., at the ILC Snowmass workshop in August).

The guidance from EPP2010 is that it is looking for a white paper on the physics related to the LHC and linear collider. This also fulfills a significant part (but not all) of the charge from HEPAP. The current draft is a white paper with an introduction and a summary table. The final version will be transmitted to EPP2010 along with a cover letter from Gilman that addresses the specific EPP2010 questions to HEPAP.

The overriding philosophy is physics first. The report is organized around the physics. It begins with the nine questions from *Quantum Universe: The Revolution in 21st Century Particle Physics*. These questions are mapped into the three basic physics themes that are most relevant for these colliders. Chapter II of the Subpanel's report explains the three physics themes.

Chapter III describes ten of the most likely and robust scenarios addressing this physics at LHC and ILC. Each scenario begins with a specific LHC discovery. Each scenario ends with an ILC discovery triggered by the LHC discovery. Typically, there are intermediate discoveries for which the relative contributions of LHC and ILC depend on details of the physics and on uncertainties in the reach of LHC analyses.

The physics scenarios are summarized in a table. The table also shows the explicit connection between LHC discovery, the resulting opportunities that require an ILC, and the *Quantum Universe* questions that are addressed in each case. The information in the table is coarse-grained, but the overall message is an accurate reflection of the 20-page narrative in Chapter III. Chapter III is itself an accurate distillation of the 500-page LHC/ILC Study report and of other studies.

The Subpanel believes that it retained the meat of the report, and at the same time the technical level was converted to something like the prose of *Scientific American*, with almost all concepts and jargon defined in the document itself. This was very difficult to accomplish.

The three physics themes are

- Mysteries of the terascale,
- Light on dark matter, and
- Einstein's telescope.

In Theme 1, resolving the mysteries of the Higgs and supersymmetry, the LHC should discover the Higgs. It should also discover supersymmetry or some other new principle that explains the Higgs's existence. The linear collider would resolve the hidden messages of the Higgs, the superpartners, and their terascale relatives.

In Theme 2, determining what dark matter particles can be produced in the laboratory and discovering their identity, most theories of terascale physics contain new massive particles with the right properties to contribute to dark matter. Such particles would first be produced at the LHC. Experiments at the ILC would establish whether they are actually dark matter and, if so, how much of the dark matter.

In Theme 3, connecting the laws of the large to the laws of the small, from a clear vantage point at the terascale, the ILC could function as a telescope to probe far higher energies. This capability offers the potential for discoveries beyond the direct reach of any accelerator that could ever be built. In this way, the ILC could bring into focus Einstein's vision of an ultimate unified theory, connecting the laws of the large to the laws of the small.

The report shows how a variety of evidence points to the TeV energy regime as a gateway to revolutionary discoveries. This is why the Subpanel is so excited about the LHC. However, "TeV scale" is a lousy name. So the Subpanel borrowed "terascale" from its friends in high-performance computing.

There are several misconceptions:

- If LHC discovers more and measures more, then there is less motivation for the ILC. This report makes it clear that the opposite is true. The LHC is important to provide guidance for building the ILC, such as the energy scale.
- Once LHC discovers a Higgs particle, the rest is details. This report makes it clear that the discovery of a Higgs particle would raise urgent questions leading to even greater discoveries. It is the start of something, not the end of something.
- The only thing colliders do is discover particles. This report explains how particles are the tools that we use to resolve mysteries and to discover new laws of nature.

The Subpanel needs HEPAP members' comments on the draft within the next week (for EPP2010) or in a month or two (for the final report).

Dehmer suggested using the word "discover" instead of "resolve" in talking about what the ILC would do in response to discoveries by the LHC. Terascale cuts both ways: It is familiar usage but comes with other meanings attached.

Dawson said that this document has the right mix of content for EPP2010.

Dragt suggested that the themes should be highlighted on page 5. He also pointed out that the 9 questions are repeated on page 7; there is a reason for that, and that reason should be made clear to the reader. He asked if the document should try to explain supersymmetry using Grassman variables. Lykken replied that he was not sure that works. It would be scientifically correct and exciting, but not easy to do.

Butler said that this should be tested out on readers, like EPP2010. Lykken agreed. Matthews volunteered to look at the document.

Cahn said that he was worried about some of the terminology that is very difficult to explain. The document is pretty heavy going. Lykken said that that is the real challenge of this document. One has to explain the problem, let alone offer a solution.

Ritz observed that the argument set forth on page 12 sounds very circular to someone who is not an expert. There are some repetitions. The Executive Summary is not distinct from the rest of the document. He asked why the document uses Einstein's "telescope" rather than "microscope." Lykken said that the Subpanel is looking at large energy scales and looking back to the Big Bang in time. Also, it is not clear that the take-home points have been highlighted clearly enough.

Staffin said that the breakthrough here is that the document tells how the ILC will make its scientific discoveries. He sensed that the Subpanel was on the right road.

Drell said that she believed that there was a missed opportunity with dark energy. Lykken agreed; the Subpanel has added a sidebar and several paragraphs on that topic in the new version.

Baker asked if the question of concurrency had been resolved. Lykken replied, yes; it is used in the discussion of supersymmetry.

Gilman suggested that the Panel members should read this report to see if it is getting across the big questions and themes that need to be gotten across to EPP2010 or if an important point is left out or if jargon is used that will be meaningless to some readers.

Staffin noted that in 2 months some members' indentured servitude will be up. He and Dehmer wanted to thank each of those members for his or her contributions: Baker, Butler, Kim, Langacker, and Peggs. Fred Gilman has been a wise advisor and spokesperson, so the DOE and NSF had a plaque with which to thank him for his important contributions and leadership. [Presentation of plaque; round of applause.]

Dehmer said that Gilman has been the only HEPAP chair that he had known. Gilman presided over the integration of DOE and NSF in HEPAP and made the process proceed to the effective level it now enjoyed. A lot has been accomplished under his leadership in developing a vision for the field of HEP. He has also led HEPAP into a high level of productivity, becoming essential to NSF in ways it was not before. [Round of applause.]

Gilman declared a break in the proceedings at 3:09 p.m. He called the meeting back into session at 3:42 p.m. and initiated a discussion of the P5 Subpanel. Abe Seidel will be the Chairman. He read the names of the members of the reconstituted Subpanel. It will look at the very broad issues of the next few years and has an appropriately international membership. It will meet September 8-9. On September 12-13 it will be at Fermilab and in October at SLAC. The overall agenda is not yet set.

Kim said that people are very happy with the current charge to P5. It would be nice to have a more official and detailed agenda available to the members so they can plan their travel and prepare presentations. Gilman stated that the recommendations from the NuSAG will come to HEPAP and be passed on to P5. Meyers noted that the P5 meeting will occur a day after the NuSAG meeting, so it will be touch and go. Gilman said he would urge Seiden to get the dates and agenda set.

Dragt urged P5 to solicit directly more foreign input at its first meeting, given the participation of foreigners in the Fermilab and SLAC meetings and the short timescale the Subpanel is operating on. Gilman suggested they might be asked to prepare something written to be submitted in advance.

Gilman opened the meeting to general discussion. Kim suggested that HEP needs to make up a strategic plan. Byon-Wagner commented that she believed that the very first task that P5 is planning to do is updating the roadmap of the HEP program. Kim stated that more people (physicists) and money probably need to be put at CERN. Gilman said that that would probably be part of the P5 inquiry. He expected that P5 would ask how the LHC program is going to ramp up and what resources would be available for the whole HEP program. Kim agreed that that would be great for them to do.

Ferbel asked if P5 will look at the LHC upgrade or just the current construction and operations. Gilman said that the charge is to look at the Tevatron, BaBar, and the LHC for the next few years, but he expected that P5 would want to know about other opportunities and everything that is ramping up.

Ritz pointed out that the charge explicitly asks if resources should be deployed elsewhere and stated that the community may want to invest heavily in the LHC upgrade. Byon-Wagner responded that, at the moment, DOE and NSF are assuming that U.S. groups will be participating in the upgrade of LHC, both of the detectors and of the accelerator. However, groups should have to submit formal proposals, including scope, cost, and schedule to be considered by the agencies. Goldberg pointed out that no one had a large pot of money. A lot of other things have to fall into place before P5 can consider any upgrades. Ritz said that HEPAP should suggest that P5 gather whatever information it can garner. Staffin suggested that it also could at least define decision points, even when there is not enough information to make a decision now.

Butler warned that, if P5 considers the LHC, it should choose its words carefully. There should be a clear understanding of what the issues are.

Peggs stated that, whatever scenarios play out, it is clear that quadrupole magnets will be part of that scenario. No one knows what the machine parameters will be. To say that the upgrade of luminosity will be to 10^{35} is just one of many scenarios.

Gilman said that it sounded like P5 will ask for information about the LHC upgrade to include in its considerations. Dehmer noted that other subpanels are looking at the LHC and ILC and that P5 was to look at other issues.

Bortoletto suggested that the information about travel money for the core research program should be more transparent. Also, the U.S. community should participate in the R&D on tracking and on silicon technology going on at CERN. Ferbel replied that there is support for that in the ongoing core programs. For new funds, one needs to go to the program managers, and they have to find the money. Gilman asked if more information about the reports could be made available. Goldberg said that the first step would be for people to look at what is available. There may be one site for that information or one could go to all three.

Kim questioned NuSAG's only looking at Phase 1 of the NOvA program and making a recommendation about whether or not to get involved while looking at Phase 2 of T2K. Meyers said that Phase 2 of T2K is not yet approved. NOvA's first phase is similar to that of T2K. If there is a signal to be seen in Phase 1 of the experiments, that means that a lot of new physics is within reach. What you get with Phase 1of these experiments is (only if θ_{13} is large enough) $\nu\mu \rightarrow \nu e^-$ oscillations. In fact, because of various ambiguities, one does not get the mixing angle directly, but one gets evidence that this occurs at a level such that a conventional beam-based experiment has a good shot at CP violation and the mass hierarchy with enough beam power. At that point, the late phases become complementary in that having two different baselines means that the two experiments together do what neither does alone, which is, perhaps, measure CP violation *and* the mass hierarchy. It is a complicated issue: the first phases do not do that much physics and, if they do, they do similar physics. The later phases are distinct, and T2K in its second phase does not measure mass hierarchy; and without mass hierarchy, it has certain regions of sensitivity to CP violation. Likewise, NOvA, with a proton driver, for example, has difficulties sorting out different ambiguities. But together they have an enhanced reach over each of them alone. It is not a head-to-head competition between the two experiments, and it is not that either can do what the other can. It simply is not that way. Together, they are complementary. A program is more interesting if it has a viable upgrade path. One question is whether the United States wants to be involved in this game at all through NOvA or if it is sufficient to take part in this kind of long-baseline neutrino oscillation in Japan and do something else. That is what one is faced with. An experimental program that ended with a significant observation of $\nu\mu \rightarrow \nu e^{-}$ appearance but could not do anything else would not be interesting. It is more interesting if there is some degree of complementarity. It gets complicated as one puts more money into detectors, the accelerator, or both.

Ritz said that the Subpanel should look for cases of overselling in the LHC/ILC Subpanel report. Every statement in this report is a simplification and opens it to misinterpretation. The case is strong enough without overselling. Cahn stated that the report should spell out how the LHC is expected to make the science case. The question of LHC's failing to find something is not a reasonable scenario. Staffin reiterated that something should be said about why one is drawn to expect something out of the LHC. Langacker said that the fact that the success of the electroweak theory is measured in the 0.1% level really calls for a symmetry breaking either at the very low mass scale (<200 GeV) or something that mimics it very well. That task is extremely difficult. What gets stickier is if one has the Higgs plus something else to protect the electroweak scale. He had not seen any scenario that says that there is nothing new to see at the LHC, including the possibility of strong w-w scattering. Womersley said that that cannot be the whole story. There is another degree of freedom. What if it cannot be seen with a 500-GEV machine? One needs to look at the question of whether a 500-GeV machine or something else is needed.

Gilman adjourned the meeting for the day at 4:27 p.m.

Tuesday, July 12, 2005

Chairman Gilman called the meeting to order at 9:04 a.m. He announced that Jay Marx would be the Chair of the Accelerator R&D Subpanel. He introduced **Raymond (Chip) Brock** to give the final report on the survey of physicists in HEP through the end of the decade.

About a year ago, a task force was formed by HEPAP to investigate the projected "needs" of experiments and "plans" for all U.S. HEP groups. The Subpanel was asked if the field had the manpower to carry out the experiments to which the U.S. program is committed until the end of the decade. A survey was conducted of two communities: 18 experiments selected by the committee and 194 DOE and NSF PIs. A questionnaire was sent to the experiments, asking them to evaluate their needs in operations (carefully defined) and analysis (carefully defined) from 2004 to 2009 in terms of faculty/staff, post docs, and students. 2004 was treated as a census year; foreign and U.S. personnel were considered separately. A questionnaire was sent to the PIs, asking them to evaluate their plans for faculty, research associates, postdocs, and graduate students for all projects from 2004 to 2009 under a severe, constant-effort boundary condition.

He listed the committee members.

Before the previous HEPAP meeting, the Subpanel jointly prepared letters of introduction and instructions plus spreadsheets, including examples. They were sent to (1) all NSF experimental EPP grant PIs, including the Cornell Electron Storage Ring

(CESR); (2) all DOE/HEP grant PIs, including FNAL, BNL, SLAC, Argonne National Laboratory (ANL), LBL, MIT Laboratory for Nuclear Science (MITLNS); and (3) spokespersons of the selected 18 experiments. From September through April, the Subpanel reminded, cajoled, begged, and threatened PIs and spokespeople to respond. Eventually, nearly 100% of the PIs responded in a useful way, and all experiments replied.

At the previous HEPAP meeting, the Subpanel presented the experiments' responses and integrals of the PIs' responses.

Since the previous HEPAP meeting, data have been added for one missing university and one missing laboratory. The PI information was also added for comparison. The data were hand-checked to ensure there were no errors. Subsequent discussions centered on the Tevatron experiments, and discussions were held with several groups. The Subpanel met electronically for a second time to discuss results and to fashion its conclusions.

The PI response from universities and laboratories was completed for 194 groups, 81 supported by NSF, and 136 supported by DOE. Some were funded by both agencies. There were 53 projects with two or more PIs responding. The respondents made up 603 group-projects, with about three projects per group, including, for 2004, 717 total faculty, 340 research scientists, 547 postdocs, and 712 graduate students.

The graphic presentation of results shows that the Subpanel pretty much covered the field for particle physics.

Counting faculty is difficult. The Subpanel used percentage of research fraction (RF) as a metric, which allowed for a variety of comparisons and easy checking that the constant-effort rule was followed because it sums to a name. However, RF over counts full-time equivalents (FTEs). Experiments use FTEs for postdocs and graduate students. But, essentially, FTE = RF. A standard in experiments is a 50% efficiency factor for faculty time. For laboratory scientific staff, RF is considerably higher than 50%. So, an estimated FTE (ESTFTE) was used for faculty counting: ESTFTE = 0.5(university professor RF) + (laboratory scientific staff RF). Postdoc and graduate-student counting totally correlated to faculty involvement (e.g., a 20% faculty person implies at least one student and/or one postdoc, while a 0% FTE faculty person implies zero.

The word "needs" is relatively straightforward for operating the experiments; the error is estimated at ±10%. The meaning is considerably less straightforward for analyzing the experiments. The same people do both, sometimes at different times during their involvement. Analysis intensity follows the integrated luminosity jumps. For future experiments, the estimate is of something other than "need." It was reported as consisting of basically a mixture of real effort now ongoing in construction (like operations in running an experiment, again ±10%) plus a census of what groups intend to do in the future.

The PI database contains a lot of information about what people are doing in high-energy physics. One can plot personnel needs over time by type of experiment (accelerator-based neutrinos, neutrinos, ILC, etc.). Then one can look at the results from 17 experiments in current (ongoing) and future terms. The Subpanel canvassed 75 to 80% of all experiments with the chosen ones. It did not ask for U.S. scientists needed. It took the total needs and benchmarked them to the 2004 U.S. actual ratio. That U.S. portion is what was reported. The data for different experiments were compared. There was good consensus between the PIs and the institutional spokespersons. For D0 and the Collider

Detector at Fermilab (CDF), one-third of the need was in operations, and two-thirds was in analysis.

On the basis of the PI data, there is a falloff on the Tevatron plans and a nearly linear increase of people migrating to the LHC. If all collider experiments are put together (D0 + CDF + BaBar + CLEOc) and one compares those numbers of people added to the U.S. ATLAS and U.S. CMS and then they are added together, one gets a nearly constant sum. This is a fairly closed set. On the basis of the institutional-spokesperson data, there is a rise in need (or anticipated need) as one goes from the current experiments to the future ones.

The Tevatron situation presents special challenges. Therefore, there was a special follow-up in June, focusing on the Tevatron. There is an apparent correlation among about 80 independent D0 and CDF PIs. A significant PI decrease occurs, especially after 2006. One difficulty is in defining "needs" by the experiments, and there is almost no certainty in predicting beyond FY08. This is all theoretical; nothing has happened yet. It suggests a potential problem to be investigated. Questions linger: Are these the real "needs" of the experiments? Are these the real "plans" of the PIs? The constant-effort rule was very difficult to contend with for PIs.

The Committee concluded that they would send D0 Run Ib + CDF Event Builder representatives a questionnaire that included the following questions for anonymous reply:

- Do these results surprise and/or concern you?
- Would you have liked to have kept a greater presence in D0 or CDF during the period from 2006 to 2009 than your response suggested?
- If you would have, what led to your decision to respond with a significant reduction in plans for CDF or D0?
- What factors influenced your projection to 2007?
- What would you have needed to believe about your particular circumstances in order for you to have responded with a greater presence in D0 or CDF?
- Should CDF and D0 collaborations just live with this apparent plan or should the Tevatron community promote a managed transition? Do you have a sense of what would constitute a managed transition?
- Would these apparent results have led you to have responded differently if you had known beforehand?

A draft of the questions was tried out on a few D0 people. One reported back, "One positive thing that I come away with is a greater sense of duty to DZero. I can't now assume that other groups will keep DZero running as we shift to CMS."

In the results from the questionnaire, everyone emphasized that outstanding physics will come from the Tevatron. The redirection of physicist resources can compromise the physics. Premature migration would prevent postdocs and graduate students from gaining experience necessary for LHC analysis. Two issues dominated any shift from Tevatron to LHC:

- Some physicists need to participate in LHC on Day 1.
- Some reported implicit and/or explicit directives from agencies to shift from Tevatron to LHC.

Among these respondents, 60% say "physics," and 45% say "pressure" (including 9% who say both).

The constant-effort constraint was a reason for an apparent coherent response away from Tevatron. 65% said that, with incrementally more resources, they could devote additional students or postdocs to the Tevatron program. Small groups have a special problem because they have to make an either-or decision. Essentially all were in favor of a "managed" transition. Some suggested

- specific ideas for streamlining of operations, analysis, and code changes;
- more inclusion of laboratory technical people into traditionally physicist roles;
- prioritizing of physics goals;
- the need for close coordination among stakeholders, leading to a strategy; and
- assurance that those who conformed would not suffer funding loss.

These responses were made in the framework of a constant-level of effort from the PIs. They were done in the context of three time-dependent uncertainties:

- The potential for exciting physics results,
- The uncertainty in the LHC schedule, and
- The uncertainty of the Tevatron's and B-Factory's future luminosity performance.

The Subpanel concluded that maximizing the physics return from the Tevatron and BaBar while simultaneously preparing for an active U.S. role in ATLAS and CMS may tax physicist resources of the U.S. HEP community, especially when factoring in the other efforts planned and under way in neutrino physics, astrophysics, cosmology, and cosmic-ray physics. With respect to the Tevatron and LHC, the next 2 years will be crucial in terms of understanding the evolution of the three uncertainties cited above, but the field cannot wait to see whether this will prove to be the case. Although one cannot be sure that additional resources will be required, navigating this transition will require an unprecedented, active coordination among (1) the running collider experiments (primarily, BaBar, D0, and CDF), (2) their laboratory managements, (3) U.S. ATLAS and U.S. CMS, and (4) the funding agencies to ensure it does not become a real problem.

There might be a serious problem at the Tevatron beginning within 1 to 2 years for those groups trying to evolve to LHC while simultaneously maintaining sufficient strength in CDF and D0. (For BaBar, this situation appears to be less severe at this point.) A focused effort on helping to maintain the Tevatron and B-Factory efforts of a small number of specialized groups/personnel may be required to alleviate potential problems. If necessary, a few-year supplement to the University Program budget could be required. The coordination should start immediately, and conclusions should be reached in a matter of a few months so plans can be formulated and remedies negotiated very soon.

He offered his personal opinion that the community will get through this, but only with a significant effort. It is far better to uncover a potential problem now and fix it than to wait until it is too late. All that can be done with average FTE-counting has been done. The fact of the matter is that all FTEs are not the same. It is time for the stakeholders to start identifying named individuals and groups and matching them to specific systems and roles. Also, they need to identify important senior physicists trying to split their efforts but finding it difficult because of resources. It will be hard. The burden is on the experiments and the national laboratories to identify critical groups' needs. There needs to be an iteration to a solution among experiments, laboratory managements, and funding agencies. The responsibility is with the agencies to make particular groups capable of doing both. All this needs to be done in a few months.

Perceptions have driven a significant part of this survey. NSF and DOE need to learn to encourage research at the Tevatron. This need does not come through as much as it should. This situation is a great one-time opportunity to change those perceptions. The Next Big Machines seem to dominate the agencies. Data-in-hand deserves better attention, especially given the enormous physicist and financial investment.

Physicists discover things. One has to remember how physicists do that: they hit some home runs (charm and quarks) but also small base hits (exquisite resolution of the Z mass). But careful, precise measurements only come with experience and long effort. Fermilab and SLAC are the careful, precise measuring places. That is a balanced program.

He thanked the myriad people who helped complete and analyze this survey and its results.

Gilman thanked him for this enormous effort.

Langacker asked to what extent the BTEV cancellation is reflected in the numbers presented. Brock said that it is not there. It would be at the level of tens of FTEs. Langacker asked if he was talking about getting junior people into the LHC now. Brock replied that it is difficult for small groups to split their effort between senior and junior faculty members. Kim commented that, even in larger groups, the junior people have greater needs for research experience, and senior people have more experience to offer.

Ritz noted that it would be good for P5 to see this presentation before it visits Fermilab. Brock agreed.

Stanfield said that Piermaria Oddone, the Director of Fermilab, had asked him to make some comments on the physicist resource survey. He thanked the Subpanel members for their hard work and thoughtful consideration. The survey has verified that, in the constant-budget scenario, there must be a redirection of physicist manpower from other efforts to CMS and ATLAS at the startup of the LHC physics program. This redirection reflects real forces at work, but has many uncertainties, especially as projections are made further into the future. Run II is going very well, and its biggest potential still lies ahead. A plan is needed on how to get the physics out of CDF and D0. The work of the committee correctly identifies that the transition to the LHC from the domestic program is something that needs to be well managed. It will take the joint efforts of the collaborations, PIs, the Laboratory, DOE, and NSF to reach a good solution. The Laboratory will work with all of these to make certain that the great physics potential of Run II is realized. There are many options to consider on how to address the issue, and it will take some time to come up with an optimized plan. Work is already under way:

- Both collaborations are negotiating MOUs with their collaborating institutions that are more specific on FTE commitments.
- The LHC Physics Center at Fermilab will help in the transition for those physicists working at Run II and CMS.
- The collaborations are continuing to refine their understanding of what is needed.
- The Laboratory is considering how to make the operation of the detectors more efficient in their use of manpower.
- It is also looking at ways to use technicians, engineers, and software professionals to reduce the effort required from scientists.
- The Laboratory will need to shoulder a larger burden. Fermilab is committed to working with the all stakeholders and will take concrete steps to develop and

implement a plan that works.

Stanfield also announced that electron cooling had been demonstrated at the recycler of the Tevatron on the previous Sunday. With 42^{10} pbars in the recycler, the longitudinal emittance was reduced from about 18 eV-sec to about 8 eV-sec in a little more than an hour. At the end of that period, a predicted beam instability was observed. These results seem to be consistent with design expectations.

Goldberg told Brock that this is a model survey and asked if there were an easy way to see if it bears fruit (e.g., reviewing the situation each 2 years). Brock replied, yes, it could be done but would take a good deal of effort. And a good deal of persistence, added Gilman. Siegrist pointed out that the numbers measured might not tell one if the issues were addressed. Ferbel proclaimed that a disaster is approaching: most faculty members will not send graduate students to the Tevatron. The attraction of the LHC will be enormous for graduate students. Goldberg said that he had observed the same thing.

Kim pointed out that, although the PI responses assume constant funding, supporting someone at LHC will be more expensive. Brock agreed that the cost of living at CERN is greater than that in the United States. A CERN postdoc costs more; that will affect the number of personnel that can be supported in the United States as well as at CERN. Dragt asked what the increment was. Brock replied, at least 30%.

Staffin thanked the team for its hard work. This is a real near-term challenge. It is good the agencies got this warning. Billions have been put into Tevatron and BaBar, and the agencies are committed to getting the physics out of those experiments. There is no simple solution; everyone will need to work together, and the agencies welcome Fermilab's offer to cooperate. The national laboratories will share more of the burden of running these experiments. HEP will steer as much support to this effort as possible. His view was that resources should not be being moved to the LHC right now. All the players need to work through this situation together.

Dehmer thanked the Subpanel for its efforts. DOE and NSF got an extremely clear signal from this survey. This is an important wakeup call. A similar challenge exists with CESR and CLEO. These decisions have to be made wisely. One needs to figure out how to proceed and where the next signal will come from.

Goldberg stated that the data still need to be analyzed, and the centers at Fermilab and elsewhere can provide the skills and tools for such analyses and prepare people to transition to the LHC.

Kroll stated that this is an issue of physics. One should think about what could be done with more resources. The work at the LHC is long-term and may face delays. A lot of work can be done at the Tevatron in the meantime. D0 and CDF are large collaborations. But personally, he would want to have a presence at the LHC.

Butler said that the investments at the Tevatron need to be capitalized on. The operations model will have to change, Kroll added, and it will have to be done faster. Butler went on, one will need to figure out the transition from the operations and analysis sides.

Ruchti pointed out that, over the years, many of the people at the LHC have been older. Young people need to get involved. What is needed is to train people that have broad interests, not just an interest in analysis.

Cahn asked how good an approximation this sampling of collider programs was. Brock said that he did not show those correlations, just flattened data. It was not analyzed at that level; he expected it was within tens of FTEs. Gilman said that the number is small, but people are moving out of colliders and into other fields of physics.

Ritz observed that the next steps should come out of a collaboration. They know where to train students, the physics to be done, and what can be done with the Tevatron.

Kim stated that these studies are very valuable; they provide a wide view of the situation.

Blazey said that researchers want to know where to go until 2007; they will need help from DOE and NSF and from FNAL. It is important to keep the project healthy until 2007. Dehmer agreed that 2007 is an important point in the planning cycle. If one could give students a stake in both the data being produced at the Tevatron and in the LHC, that would be very attractive to them. Blazey said that that would drive institutional administrations crazy. Brock said that it is partly cultural; it is done in space-based physics. Kroll said that that could have been done in years past, but it is important to be at the LHC *now*. Students will find it very difficult to split their time between Tevatron and the LHC.

Gilman declared a break at 10:25 a.m. and called the session back to order at 10:43 a.m. He introduced **Bruce Winstein** to present the final report of the Cosmic Microwave Background (CMB) Task Force, provide perspectives on the field, and identify how and why DOE/HEP might contribute to the effort.

Winstein noted that the membership of the Task Force is drawn from a broad range of institutions and subject areas and includes observers. Its most important scientific finding is that a unique CMB polarization signal on large angular scales directly tests inflation and probes its energy scale. The Task Forced recommended that a phased program be established to measure the large-scale CMB polarization signal expected from inflation and to test whether GUT-scale [Grand Unification Theory] inflation occurred by measuring the signal imprinted by gravitational waves to a sensitivity limited only by the ability to remove the astrophysical foregrounds.

The Task Force is recommending a phased science program that begins with a strong ground- and balloon-based program that will make polarization measurements on small and medium angular scales and culminates in a space mission for angles larger than 1° specifically optimized, for the first time, to measure CMB polarization. The Wilkinson Microwave Anisotropy Probe (WMAP) and Planck were not so optimized. The Task Force estimates that limits at or below $r = 0.01$ can be set on the amplitude of primordial gravitational waves; to reach this level, a sensitivity at least 10 times that of Planck will be required.

Polarization measurements between 10 and 90° can only be done by satellite. Data from the Degree Angular Scale Interferometer (DASI), Cosmic Background Interferometer (CBI), WMAP, Cosmic Anisotropy Polarization Mapper (CAPMAP), and Boomerang below 1° are not precise but agree with the Standard Model of cosmology. Theoretical plots indicate a goal of measuring something in the region of a temperature anisotropy of less than 0.10 μK and a multipole moment of less than 11. The same plots indicate the GUT scale to fall in the same range of temperature anisotropy (down to 0.001 μK) between 10 and 0.2°. Data from WMAP at a temperature anisotropy around 2 μK and a multipole moment between 2 and 10 showed that the universe got re-ionized.

Cosmological inflationary models can be tested by mapping the tensor-to-scalar ratio (i.e., energy scale) against the scalar spectral index. Large portions of this mapping of inflation can be ruled out by CMB and by large-scale cosmological-structure measurements, leaving a small portion of allowed values.

In the desired region of polarization measurement, the foregrounds (dust and synchrotron radiation) are going to dominate the measurements. Estimates of the dust and synchrotron-radiation foregrounds have been made from satellite measurements like POLAR [Polarization Observations of Large Angular Regions]. These foregrounds will need to be known exactly so they can be subtracted from the signal to leave the polarized CMB.

The second science recommendation made by the Task Force is a program to measure the temperature and polarization anisotropy on small angular scales. The predicted sensitivity of a 1000-element detector on the ground would preclude observing polarized CMB, although such a detector might observe gravity waves at the lower end of the GUT scale. In addition, from lensing measurements, one can measure the mass of neutrinos to interesting levels.

The Task Force's third science recommendation is a systematic program to study polarized astrophysical foreground signals. Estimates based on E- and B-mode signals indicate a lot of uncertainties in the synchrotron-radiation and dust foregrounds. One needs to make a lot of measurements at a variety of frequencies, which can be seen from space.

The Task Force's first technology recommendation is the development of receivers that contain a thousand or more polarization-sensitive detectors and the provision of adequate support for the facilities that produce these detectors. To sustain this work, $7 million per year for the next 5 to 6 years is needed. This would roughly restore the pre-2003 level of funding for the field. It is important to keep open a variety of approaches until a clear technological winner has emerged. Nevertheless, highest priority needs to be given to the development of bolometer-based polarization-sensitive receivers. In these devices, planar antennas with orthogonal slot dipoles produce signals, the heat from which is dumped on a bolometer, and the difference between two orthogonal antennae is measured.

The Task Force's second technology recommendation is the adoption of a strategy that supports alternative technical approaches to detectors and instruments. Advances in CMB science have been based on a variety of technologies. Though it is expected that bolometers will be the clear choice for the CMBPOL [CMB Polarization] satellite, it is premature to shut down the development of alternatives. The Task Force recommends the continued development of detectors based on high electron mobility transistors (HEMTs) because they might lead to an alternative space mission with reduced sensitivity. Under development at the Jet Propulsion Laboratory is a prototype HEMT polarimeter with two frequencies: 90 GHz Q/U and 40 GHz Q/U.

The Task Force's third technology recommendation is funding for development of technology and for planning for a satellite mission to be launched in 2018. Another need is for modeling the mission, preparation for a 2011 announcement of opportunity, and a 2018 launch with funding starting at $1 million in 2007 and rising to $5 million per year in 2011.

The Task Force's fourth technology recommendation is strong support for CMB modeling, data analysis, and theory. This recommendation is very important.

He showed a schematic timeline of research programs observing CMB small-scale temperature fluctuations, CMB polarization, and the Sunyaev-Zel'dovich effect. This timeline for funded experiments included three satellite experiments (WMAP, Planck, and CMBPOL), balloon experiments, telescopes, other ground experiments, and technology development. A good deal of the technology development must be completed by the 2011 launch of CMBPOL. These ground-based HEMT, ground bolometer, and balloon bolometer experiments each face challenges (e.g., cryogenic techniques, the development of 1000-antenna arrays, data analysis, Superconducting QUantum Interference Device (SQUID) multiplexing, and polarization modulators), and all of them lead to CMBPOL, whose goal is to produce a polarization map down to the fundamental astrophysical foreground units.

The needed CMB funding totals about $25 million a year between 2004 and 2011. These funds cover satellite mission technology (which is constant), satellite mission planning (which emerges in 2006 and increases steadily through 2011), theory (which is constant), balloon-borne receivers and experiments (which peaks about 2008), ground-based receivers and experiments (which peaks about 2006), and detector technology (which peaks about 2006).

Predictions of future satellite sensitivities indicate that missions that would cover the area of interest on the temperature anomaly–multipole moment plot would be too expensive to do entirely from space. It would be better to focus on wide-angular-scale missions. The ultimate mission faces severe challenges in instrument performance in terms of cross-polar-beam response, main-lobe ellipticity, polarized sidelobes, etc.

In this field, the science is certainly fundamental, the scientists are first rate, and the field is really starved for resources. Manpower funding is tied to projects, researchers work on multiple projects, and there is intense competition (only a small fraction of proposals is being funded, and some researchers are getting disillusioned). It is not clear that the agencies really know the funding situation. No one body is reviewing proposals and progress. The collaborations are often not too smooth. There is very little open discussion of progress and problems. There is a phase transition under way in moving to 100- and 1000-element arrays. Research will be more expensive with larger groups and a need for engineering and management. The kind of planning in the Task Force report is what was recognized as what is needed.

One might ask about the role of HEP. Inflation is an extraordinary idea that is outside the Standard Model. It is also a very rich phenomenology, unlike dark energy, which just has one value. There are agency problems. There is a big crunch at NSF, and it is uncertain if the National Aeronautics and Space Administration (NASA) is going to support ground experiments. It is exciting to work with extremely low-noise requirements in the signal-to-noise regime of 10^{-8}. One has to integrate 1000 or more detectors for more than a year. There are warm electronics, data analysis, large-scale computing, engineering, and management, all of which this field needs.

The search for CMB polarization offers an ideal arena for DOE, NASA, National Institute of Standards and Technology (NIST), and NSF interagency cooperation. Indeed, given the need for receiver development, ground-based observations, foreground characterization, and a space mission, the road map *requires* such cooperation.

Kim asked how this field will evolve in 50 years. Winstein replied that, 7 years ago, he was told that this field was over. It is very exciting now. The community has to embrace bigger groups, cooperation, and management.

Cahn asked how the $25 million is divided among agencies. Winstein answered that DOE's portion would be small (10%); most would come from NASA (1/2) and NIST (1/3). Baker asked if this included launch costs or just detector development. Winstein replied, just detector development. He expected that the three agencies would discuss these recommendations to see what could be done.

Ritz noted that there is a lot of technology that one can do in the near term, but there is no mention of that. He asked if a CMB SAG was in order. Winstein replied that he thought that a SAG would be better but that it could not be sold right now. Conferences garner only 80 to 100 participants, including foreign nationals.

Dragt asked how one reads a bolometer. Winstein answered that one uses a thermistor to digitize the signal. Several thermal edge-sensitive detectors (TESs) are being developed.

Ritz asked if the report was public. Sharp replied that it would not be public until HEPAP and AAAC approve it. Ritz wondered how the panel could comment on and vote on the report. Gilman replied that, if one knew that there was going to be a next meeting, one could schedule a vote. Strauss said that the report could be sent to all the members of the Panel by e-mail and they could be asked for comments with a deadline of July 31, 2005.

Dragt asked if NASA might change its current priorities regarding Moon and Mars. Siegrist said that it is probably not appropriate to comment on that.

Gilman stated that he would look for comments on the report by July 31 and then go from there via e-mail. He opened the floor for general discussion. He noted that NuSAG should be submitting recommendations to HEPAP and NSAC on neutrino double-beta decay by August and on reactor experiments by the end of September. The recommendations on neutrino double-beta decay will be circulated to the Panel by e-mail with comments due back by the end of August. The recommendations in September will have to be dealt with somehow. NSAC may meet August 29, 2005. The decision by the NSB on August 11 about RSVP will be important; Gilman will transmit information about the decision to HEPAP members. The final decision on the underground laboratory is coming soon, also. The LHC-ILC Subpanel will continue and within two weeks will have a new final draft to go to EPP2010 with a cover letter from the HEPAP chair; any last-minute ideas can be forwarded to Gilman. P5's agenda will be sent out, when available. The cooperation among DOE, NSF, and laboratory managements to plan the Tevatron-to-LHC transition strategy needs to be undertaken. The CMB task force report will be out within hours and will be acted on.

Myers pointed out that the next HEPAP meeting will have many different members, and suggested that a context be provided for the new members. Staffin acknowledged that that is very true and requested suggestions on how to provide such context. Myers asked if, with so many subpanels under way, that would be the focus of HEPAP. Staffin said that he saw HEPAP as being integral with its subpanels. The full panel should critically assess the products of the subpanels. He would reserve the right to reject any recommendations if there were no solid debate of issues. The process of developing recommendations and the interactions that occur during that process are very important. A process is needed that airs all issues, but it also needs to fit in a budgetary box. HEPAP is evolving to that point.

Kim noted that, if one knows in advance what will be discussed, the panel members can be better prepared for such discussions. Gilman commented that, during the past 6 years, the role of HEPAP has evolved significantly, employing many subpanels and reporting additionally to the NSF. The agencies are coming more and more to HEPAP for advice, placing more responsibility on the Panel. Also, the Panel's subpanel documents are going out to a very broad audience, making the field understandable to many people. All those roles have changed and should continue. People need to think very hard about how to make the field understandable to those outside it.

Cahn observed that the P5 charge has it reporting at the end of October and asked how HEPAP will vote on reports after September 30. Staffin replied that HEPAP will be reconstituted soon after September. Ritz asked if that meant that there will be a HEPAP meeting in November. Staffin replied, November 2005, yes.

There being no further discussion, Gilman adjourned the meeting at 12:05 PM.

These minutes from the HEPAP meeting held on July 11-12, 2005 at the Madison Hotel, Washington, D.C. are certified to be an accurate representation of what occurred.

Fred Gilman

Fred Gilman
Chair
High Energy Physics Advisory Panel